TITLE OF THE INVENTION

ELECTRON MICROSCOPE INCLUDING APPARATUS OF X-RAY ANALYSIS AND METHOD OF ANALYZING SPECIMENS USING SAME

5 BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an instrument system including an electron microscope, for use as means for observation, analysis, and evaluation in

10 research/development and manufacture of electronic devices and micro-devices such as a semiconductor device, liquid crystal device, and magnetic head.

Description of the Related Art

In the case of manufacturing devices like a memory,

15 there are cases where foreign particles generated in the course of a manufacturing process are mixed therein. Examples of the foreign particles include foreign species particles attributable to process material as represented by residue of etching, and residue of resist, wall material

20 of process vessels, material for fixedly holding a wafer, and material for vacuum gas line etc. Adhesion of the foreign particles to a wafer results in generation of defective items at times.

It is important from the viewpoint of improving a

25 yield of manufacturing devices to analyze respective

elemental composition of the foreign particles adhered to a wafer, and to search for generation sources of the foreign particles on the basis of their kinds, thereby removing the causes of generation thereof.

5   As means for obtaining information on the elemental compositions of specimens, there has been known a technique of irradiating an electron beam, thereby detecting X-rays as generated. The X-rays comprise a characteristic X-ray emitted when electrons of atoms on the surface of, and in

10 the vicinity of the surface of specimens falls from an excited state into a lower energy state, and a continuous X-ray at an energy level below the energy of an incident electron beam due to braking radiation whereby incident electrons are braked before emission. The characteristic

15 X-ray has energy inherent to respective elements, indicated by K, L, and M lines, respectively, depending on the excited state of the characteristic X-ray. Accordingly, the elemental composition of specimens can be found by analyzing energy at peaks appearing in a spectrum. This method is

20 called an energy dispersive X-ray spectroscopy (EDX or EDS). Instruments for this method, supplied by companies such as Oxford Instrument, EDAX, TermoNORAN Instrument, and so forth, are available in the market, and are capable of making both qualitative analysis and quantitative analysis. Users

25 can find the elemental composition of specimens by analyzing

obtained spectra by means of qualitative analysis and quantitative analysis, respectively.

Another example of a method of identifying the elemental composition of specimens from X-ray spectra is disclosed in JP-A No. 108253/1988 (public known example 1). There is described therein the method whereby respective characteristic X-ray spectra (reference spectra) of a plurality of known substances are kept registered in a memory, and by checking the X-ray spectrum of an unknown substance against the reference spectra registered in the memory, the unknown substance is identified.

An example of inspecting foreign particles on the surface of a wafer by use of the method described is disclosed in JP-A No. 14811/1996 (public known example 2). In this example, there is described a configuration wherein the locations of foreign particles are determined by observation of images dependent on the magnitude of reflection electron signals, and by checking the X-ray spectra of the foreign particles against reference spectra, the elemental compositions of the foreign particles can be identified.

Still another method is disclosed in JP-A No. 321225/2000 (public known example 3). There is described therein a method wherein the net X-ray spectrum of a foreign particle is found on the basis of an X-ray spectrum of a

portion of the surface of a wafer, having the foreign

particle, and an X-ray spectrum of the rest of the surface

of the wafer, having no foreign particle, (background

spectrum), and the elemental composition of the foreign

5   particle is found by checking the net X-ray spectrum of the

foreign particle against a database.

Further, there is disclosed in JP-A No. 68518/2001 a

method of generalizing information on foreign particles,

found by the method described above, and registering the

10   same into predetermined categories, thereby specifying

causes of defects.

An electron beam, even if focused in a narrow region,

is subjected to interaction with substance inside a specimen

upon falling on the specimen, thereby undergoing

15   scattering.   The magnitude of a scattering region is

dependent on an element as the constituent of the specimen

and an acceleration voltage of the electron beam. Figs. 18A

through 18D are views of results of calculation by a Monte

Carlo method, showing electron beam scattering conditions

20   when electron beams with acceleration voltage at 15 kV, and

5 kV, respectively, are irradiated to specimens of silicon

(Si) and tungsten (W), respectively.   In the case of the

specimen being silicon, the magnitude of a scattering region

of the electron beam is about 4 μm if the acceleration

25   voltage is 15 kV, and about 0.4 μm if the acceleration

voltage is 5 kV. Due to excitation of the electron beams, X-rays are generated substantially in these regions, respectively. This means that X-ray spectra as observed reflect information on not only irradiation points of the electron beams but also substances contained in the respective scattering regions. Accordingly, space resolving power in elemental analysis is determined not by the size of an electron beam but by the magnitude of the scattering region.

Since processing sizes of semiconductor elements that have attained miniaturization have lately reached sub-micron levels, sizes of foreign particles causing degradation in the characteristics of the elements have also become smaller. Fig. 19 is a view showing a semiconductor device structure during a manufacturing process, being matched against the respective scattering regions of the electron beams, inside Si, as shown in Figs. 18A and 18B. In the case of EDX analysis of a small foreign particle, an electron beam passes through the foreign particle, and scatters inside a substrate. Accordingly, an X-ray spectrum as observed contains information on both the foreign particle, and the substrate (background), causing difficulty with analyzing. With a substrate in the middle of a manufacturing process, in particular, patterns, that is, an oxide film, electrodes, a dielectric film, and so

forth, are formed on the substrate, and in case that flakes
from those substances constitute foreign particles, the
foreign particles need to be distinguished from those
substances.

5   Further, if the acceleration voltage is lowered in
order to reduce the effect of the background, that is, to
reduce the size of the scattering region, characteristic
X-rays that can be excited are restricted, in which case,
elements need to be identified with overlapping

10 characteristic X-ray peaks. Such an instance is described
with reference to Fig. 20. Fig. 20 is a profile showing X-ray
spectra of a titanium (Ti) foreign particle 50 nm thick,
present on the surface of a silicon wafer. The X-ray spectra
were obtained by two electron beams at 15 kV, and 5 kV, of

15 the acceleration voltage, respectively. In the case of the
acceleration voltage at 15 kV, a Ti-K line peak is observed
at 4.51 keV of X-ray energy, however, in the case of the
acceleration voltage at 5 kV, such a peak is not observed
because such a characteristic X-ray cannot be excited. In

20 this case, presence of titanium element is determined by a
Ti-L line observed at 0.45 keV of X-ray energy. However,
since there exist K-line peaks of oxygen and nitrogen,
respectively, in this region of X-ray energy,
characteristic X-ray peaks are observed in overlapped

state, if those elements are present, causing difficulty with analyzing.

Further, in the case of lowering the acceleration voltage, a generated quantity of X-ray decreases although current is sufficient for observation of secondary electron images. For example, in the above-described instance, if setting of the acceleration voltage only is changed from 15 kV to 5 kV, the generation quantity of the X-ray having the Ti-L line peak is one tenth of the generation quantity of the X-ray having the Ti-K line peak, at the acceleration voltage of 15 kV, mainly used for identification of Ti element, thereby causing a problem of degradation of accuracy in identification of elements.

Furthermore, the following problems have been encountered with the conventional methods described in the foregoing.

Analysis by software for qualitative analysis and quantitative analysis, attached to X-ray detectors available in the market, relies on a manual, which is too complicated to be used by a lay user, and is insufficient for controlling process steps, so that there has been a demand for a system automatically outputting elemental composition.

The methods according to the public known examples 1 and 2, respectively, are effective against specimens of a

uniform elemental composition, however, in the case of a small foreign particle on a substrate, there has been a problem in that even with foreign particles of an identical elemental composition, X-ray spectra thereof largely differ

5 from each other depending on a size (thickness) of the foreign particles as shown Figs. 21A and 21B, resulting in failure to match with the reference spectra stored in the database. Although it is conceivable to prepare X-ray spectra corresponding to varied thickness of foreign

10 particles, this has caused a problem of requiring longer checking time because of an increase in the number of the reference spectra. Further, since sensitivity (spectral sensitivity) against X-ray energy generally varies on a case-by-case basis due to variations in performance of X-ray

15 detectors, and difference between optical systems for detection, there is a need for preparing X-ray spectra to be prepared as a database for every instrument. Furthermore, spectral sensitivity undergoes a change over time due to stains etc. on an X-ray window, causing at times

20 a problem with checking of an X-ray spectrum.

The method according to the public known example 3 is a method wherein the net X-ray spectrum of a foreign particle is found on the basis of the X-ray spectrum of the portion of the surface of the wafer, having the foreign particle,

25 and the X-ray spectrum of the rest of the surface of the

wafer, having no foreign particle, (the background spectrum), and the elemental composition of the foreign particle is found by checking the net X-ray spectrum of the foreign particle against the data base. In this case, there

5 has been encountered a problem of a possibility that erroneous results are obtained because components of the X-ray spectrum from the background varies depending on the size of the foreign particle, that is, this is not a case of a simple linear sum of the background spectrum and the

10 X-ray spectrum of the foreign particle portion. The problem will be described by way of example with reference to Fig. 22. A figure in the left part of Fig. 22 is a schematic representation showing a case where an electron beam 8 is irradiated to a silicon wafer 20 incorporating body

15 structures 70 made of an element A. The electron beam 8 scatters in a region 71 hemispherical in shape inside the silicon wafer 20, and in the case where the body structures 70 are present within the region 71, an X-ray spectrum as observed comprises the characteristic X-ray peak of silicon

20 and that of the element A. Meanwhile, a figure in the right part of Fig. 22 is a schematic representation showing a case where a foreign particle 22 made of the element A is present on the surface of the same silicon wafer. A scattering region of an electron beam 8 will be a region 71 smaller than

25 the region shown in the left figure due to the presence of

the foreign particle 22. An X-ray spectrum as observed in this case as well has the characteristic X-ray peak of silicon and that of the element A. There are cases where the X-ray spectrum obtained in the case of the right figure

5 becomes substantially the same as that in the case of the left figure, in which case there has occurred a problem in that the peaks will disappear upon subtracting the X-ray spectrum obtained in the case of the right figure from the X-ray spectrum obtained in the case of the left figure,

10 representing the background.

SUMMARY OF THE INVENTION

In view of the problems described above, it is an object of the invention to provide an electron microscope

15 including an apparatus of x-ray analysis, capable of analyzing the elemental composition of foreign particles on the surface of a specimen with high space resolving power, high precision, and high throughput, and a method of analyzing specimens using the same.

20 The object of the invention can be achieved by adoption of the following configuration:

(1) An electron microscope according to the invention is characterized in that the current quantity of an electron beam is controlled such that the count-number of X rays from

the specimens falls within a range of 1000 to 2000 counts per second.

The electron microscope having an electron beam optical system provided with an electron source and a lens for focusing an electron beam, an optical system controller for controlling the electron beam optical system, a specimen stage on which specimens are to be placed, an electron detector for detecting electrons emitted from the specimens by irradiating the specimens with the electron beam, an X-ray detector for detecting X rays radiated from the specimens, and a processor for processing signals from both the detectors, and performing image formation and elemental analysis of the specimens, comprises means of detecting the count-number of X rays per unit time by detecting the X rays with the X-ray detector, and feedback-controlling the current quantity of the electron beam on the basis of the count-number of X rays per unit time. Further, the current quantity of the electron beam is feedback-controlled such that the count-number of X rays from the specimens falls within the range of 1000 to 2000 counts per second.

As a result, the invention can provide the electron microscope capable of securing a large generation quantity of X rays without the need for a user manually adjusting beam current, and without a risk of impairing performance of the X-ray detector.

(2) The electron microscope according to the invention may further comprise a database having data including X-ray spectra (reference spectra) of a plurality of kinds of standard substances and labels containing names of

5   substances corresponding to the respective reference spectra, and means comprising steps of:

checking an X-ray spectrum (sample spectrum) of the specimens against the reference spectra in the database;

calculating degree of matching in spectral shape

10   between the sample spectrum and the reference spectra;

extracting a reference spectrum having the highest degree of matching from the database;

setting up a plurality of X-ray energy regions so as to have sensitivity data for X-ray energy of the X-ray

15   detector, and to include peaks of the sample spectrum when analyzing by identifying substances of the specimens on the basis of the label corresponding to the reference spectrum extracted;

standardizing intensity of the reference spectra into

20   intensity of the sample spectrum for each of the X-ray energy regions as set up after multiplying the reference spectra by the sensitivity data;

checking the sample spectrum against the reference spectra as standardized and extracting one or a plurality

25   of the reference spectra in descending order of the degree

of matching between the sample spectrum and the reference

spectra for each of the X-ray energy regions; and

outputting the label or labels corresponding to the

one or the plurality of the reference spectra, the degree

5   of matching, and a numerical value used in the

standardization.

Further, a function of outputting the label, the

degree of matching, and the numerical value as described

above may output, for example, first to third candidate

10   elements in descending order of the degree of matching.

Still further, the electron microscope according to the

invention may display a intensity ratio of the sample

spectra obtained by electron beam irradiation at not less

than two varied acceleration voltages is displayed.

15   Furthermore, the sensitivity data may contain an intensity

ratio of an X-ray spectrum of a standard specimen including

a silicon wafer, obtained at the time of obtaining the

reference spectra to an X-ray spectrum of the standard

specimen, obtained immediately before matching.

20   Accordingly, it becomes possible to implement

analysis of elements which spectra are overlapped with each

other, and to obtain information on which element is

contained in a foreign particle by checking the X-ray

spectrum of the foreign particle as well as a substrate under

25   the foreign particle, in a region different in size, so that

the electron microscope capable of analyzing elements and substances with high sensitivity and high precision can be provided. Further, since difference in spectral sensitivity, between instruments, can be corrected by a correction curve using a standard specimen, it need only be sufficient to prepare one kind of database, which can be reinforced with a database acquired in another instrument without wasting the latter. Still further, even if the spectral sensitivity of the same instrument undergoes a change due to stains, etc. on the X-ray window, it is possible to effectively maintain matching with a database by acquiring a correction curve by use of a standard specimen.

(3) The electron microscope according to the invention may further comprise a memory for storing a plurality of X-ray spectra (sample spectra) at a plurality of observation points on the specimens, respectively, obtained by the X-ray detector, and means of categorizing the plurality of the sample spectra into one or a plurality of groups of the sample spectra by matching thereof with each other, and performing elemental analysis of one X-ray spectrum selected from the respective groups.

Furthermore, the electron microscope according to the invention may comprise a function of matching the sample spectra with each other for each of one or a plurality of

X-ray energy regions set up so as to include respective peaks of the sample spectra.

Further, the electron microscope according to the invention may automatically categorize the plurality of the sample spectra by matching thereof with each other, and perform elemental analysis of the plurality of the sample spectra as categorized.

Thus, it becomes possible to categorize on the basis of representative spectra without checking an X-ray spectrum obtained at every foreign particle point against a database every time the X-ray spectrum is obtained, so that the invention can provide the electron microscope capable of analyzing elemental composition of respective foreign particles in short time by matching the representative spectra only against the database, or performing qualitative analysis or quantitative analysis.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic side view of a first embodiment of an instrument according to invention, showing the configuration of the instrument in its entirety;

Fig. 2 is a schematic plan view of the first embodiment of the instrument according to invention, showing the configuration of the instrument in its entirety;

Fig. 3 is a partly sectional perspective view of the instrument according to the first embodiment of invention;

Fig. 4 is a flow chart showing a method of automatically setting electron beam irradiation condition according to the first embodiment of invention;

Fig. 5 is a profile showing an example of an X-ray spectrum obtained according to the first embodiment of invention;

Fig. 6 is a flow chart showing a method of matching X-ray spectra according to a second embodiment of invention;

Fig. 7 is a view showing a display example of output results of elemental analysis, according to the second embodiment of invention;

Fig. 8 is a view showing another display example of output results of elemental analysis, according to the second embodiment of invention;

Fig. 9 is a flow chart showing a method of performing elemental analysis according to a third embodiment of invention;

Fig. 10 is a flow chart showing a method of performing elemental analysis according to a fourth embodiment of invention;

Fig. 11 is a profile showing an example of an X-ray spectrum obtained according to the fourth embodiment of invention;

Figs. 12A and 12B are views showing the principle of operation according to the fourth embodiment of invention;

Fig. 13 is a graph showing an example of an intensity ratio between X-ray spectra according to the fourth embodiment of invention;

Fig. 14 is a graph showing an example of an intensity ratio between reference spectra according to the fourth embodiment of invention;

Fig. 15 is a graph showing an example of a ratio of spectral sensitivity for use in matching of spectra according to the embodiments of invention;

Figs. 16A through 16C are schematic representations for illustrating the principle on which a variation of the fourth embodiment is based;

Figs. 17A through 17C are schematic diagrams of X-ray spectra according to the variation of the fourth embodiment.

Figs. 18A through 18D are schematic sectional views showing dependency of electron beam scattering inside specimens, on atomic numbers and acceleration voltages;

Fig. 19 is a view showing relationship in position between electron beam scattering regions inside a specimen and a typical semiconductor;

Fig. 20 is a profile showing comparison of X-ray spectra obtained at varied acceleration voltages;

Figs. 21A and 21B are views showing dependency of X-ray spectra of foreign particles adhered to the surface of a wafer on thickness of the foreign particles; and

Fig. 22 is a schematic sectional view of a specimen

5   for illustrating difference between an X-ray spectrum of a portion of the specimen, having no foreign particle, and an X-ray spectrum of a portion of the specimen, having a foreign particle.

10   DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of an electron microscope including an apparatus of x-ray analysis, and a method of analyzing specimens using the same, according to the invention, are described hereinafter in respect of configuration and

15   operation thereof.

First Embodiment

Instrument configuration and operation according to a first embodiment of the invention are described

20   hereinafter with reference to Figs. 1 through 5. Figs. 1 and 2 show the configuration of an instrument in its entirety, and Fig. 3 shows in detail the configuration of a scanning electron microscope optical system and the periphery of a specimen stage. With the present embodiment,

25   there is shown a portion of the electron microscope

according to the invention, applicable to a wafer. Further, Fig. 3 is a partly sectional perspective view of the instrument shown in Fig. 1 although there exists some difference therebetween in respect of the orientation of the instrument and in detail for the sake of convenience in description, however, there is, in effect, no difference.

In Fig. 1, an electron beam optical system 1 and an X-ray detector 16 are suitably disposed in an upper part of a vacuum specimen chamber 60 at the central part of an instrument system. A specimen stage 24 on which a wafer 20 as a specimen is to be placed is disposed inside the vacuum specimen chamber 60. Two units of optical system 31, 41 are adjusted such that respective center axes thereof intersect each other at one point in the vicinity of the surface of the wafer 20. The specimen stage 24 has a built-in mechanism moving the wafer 20 back and forth, and from side to side, with high precision, controlling such that a designated spot on the wafer 20 comes directly below the electron beam optical system 1. Further, the specimen stage 24 has a function of rotating, turning upside down, or tilting. The vacuum specimen chamber 60 is connected to an exhaust system (not shown), and is controlled so as to be in a suitable vacuum. Further, the electron beam optical system 1 as well is provided with an individual exhaust system (not shown), thereby maintaining a suitable degree of vacuum. Wafer

introduction means 61 and wafer carrying means 62 are provided inside the vacuum specimen chamber 60. A wafer transfer robot 82 and cassette introduction means 81 are disposed so as to be adjacent to the vacuum specimen chamber

5   60. There are disposed a main controller 100 for controlling and managing a series of processes for the instrument in whole, and an X-ray detector controller 101, on the left side of the vacuum specimen chamber 60 so as to be adjacent thereto. The main controller 100 and the X-ray detector

10 controller 101 are set up such that data can be mutually exchanged therebetween, and the main controller 100 can control the X-ray detector controller 101.

Now, an operation of wafer introduction, according to the present embodiment, is broadly described hereinafter.

15 When a wafer cassette 23 is placed on a table of the cassette introduction means 81, and a command for starting the operation is issued from the main controller 100, the wafer transfer robot 82 takes out a wafer 20 as a specimen from a designated slot inside the wafer cassette 23, and

20 orientation adjustment means 83 shown in Fig. 2 adjust orientation of the wafer 20 toward a predetermined position. Subsequently, at a point in time when a hatch 64 in the upper part of the wafer introduction means 61 is opened by the wafer transfer robot 82, the wafer 20 is placed on a stage

25 63. Upon closing the hatch 64, air is exhausted by vacuum

exhaust means (not shown), and thereafter, the wafer carrying means 62 picks up the wafer 20 on the stage 63, placing the same on the specimen stage 24 inside the vacuum specimen chamber 60. In this connection, the specimen stage

5   24 is provided, as necessary, with means for chucking the wafer 20 to correct warpage thereof or to prevent vibration thereof.

Next, referring to Fig. 3, the electron beam optical system and X-ray detector are described. With the electron

10 microscope according to the invention, the electron beam optical system 1 comprises an electron gun 7, an electron lens 9 for focusing the electron beam 8 released from the electron gun 7, an aperture 3 for cutting unnecessary portions of the electron beam 8, a blanking coil 4, a Faraday

15 cup 5, an electron beam scanning coil 10, and an objective lens 11. The Faraday cup 5 has a through- hole for allowing the electron beam 8 to pass therethrough, and the blanking coil 4 deflects the electron beam 8 from the through-hole of the Faraday cup 5 only when measuring current of the

20 electron beam 8 before causing the electron beam 8 to fall on the Faraday cup 5. Besides the above-described components, there are provided a secondary electron detector 6 for detecting secondary electrons from the wafer 20, emitted upon irradiation of the electron beam 8 onto the

25 wafer 20, the specimen stage 24 which is movable and on which

the wafer 20 is placed, the X-ray detector 16 for detecting X rays radiated from the wafer 20a at the time of the irradiation of the electron beam 8 onto the wafer 20, and a reflection electron detector (not shown) for detecting

5 reflection electrons emitted from a specimen. The electron beam optical system, specimen stage, secondary electron detector, and reflection electron detector are controlled by the main controller 100.

Now, with the present embodiment, there is broadly

10 described hereinafter a process of evaluation mainly on elemental composition after introduction of the wafer 20.

Upon the electron beam 8 falling on the wafer 20, secondary electrons and reflection electrons, reflecting the surface geometry of the wafer 20, are emitted from the

15 surface of the wafer 20, and at the same time, there are produced X-rays containing characteristic X-rays having energy inherent to elemental composition of portions of the wafer 20, in the vicinity of electron beam incident regions. By moving the specimen stage 24 such that a desired

20 observation region on the wafer 20 comes directly below the electron beam optical system 1, the electron beam 8 is caused to scan the surface of the observation region with a deflection lens, and foreign particles on the wafer 20 are observed on the basis of secondary electron images and

25 reflection electron images, obtained by detecting the

secondary electrons and reflection electrons emitted from the wafer 20, adjustment being made such that the foreign particles are positioned at the center of the observation region. Subsequently, X rays produced by irradiation of the foreign particles with the electron beam 8 kept in stationary state are detected by the X-ray detector 16, thereby obtaining an X-ray spectrum. Thereafter, by analyzing the X-ray spectrum, elemental composition of the foreign particles is found. The X-ray spectrum and results of analysis are shown on a display inside the main controller 100, and are stored in a memory at the same time. On the basis of the coordinates of a position of each of the foreign particles on the wafer 20, obtained by an optical foreign particle inspection apparatus, the specimen stage can be controlled such that the foreign particles enter the observation region.

As shown in Figs. 18 and 19, acceleration voltage of the electron beam 8 is characterized in that the lower the acceleration voltage is, the smaller the scattering region of the electron beam 8, inside the wafer 20, becomes. When observing the foreign particles on the wafer 20, electrons penetrating through the foreign particles scatter inside the wafer 20, so that a substance, existing in the vicinity of regions underneath the foreign particles, is mixed as a background noise into the X-ray spectrum as observed.

From the viewpoint described as above, it can be said that the lower the acceleration voltage is, the more convenient it is from a point of elemental analysis of the foreign particles. This is effective particularly when body structures composed of several elements are formed in the vicinity of the surface of the wafer 20. On the other hand, if the acceleration voltage is lowered, the characteristic X-rays that can be excited are restricted, so that the elements that can be analyzed are also restricted. Accordingly, in the case where semiconductor elements submicron in size are being formed, the acceleration voltage at several kilovolts (kV) is adopted.

A high count-number of an X-ray spectrum with high-energy resolving power is necessary for elemental analysis with high precision. With the X-ray detector according to the present embodiment, use is made of a cooled silicon semiconductor detection element, and in order to take measurements without impairing energy resolving power and efficiently, that is, with minimum omission in counting, it is preferable to cause X rays ranging from 1000 to 2000 in number to fall on the specimen per second. The count-number of X rays per second is called an X-ray count rate, and cps (counts per second) is generally used as units thereof. With the present embodiment of the invention, the

X-ray count rate can be measured with the X-ray detector controller.

In the case where electron beams of an identical current strength are irradiated onto a silicon wafer with acceleration voltage at 15 kV, and 5 kV, respectively, the X-ray count rate in the case of 15 kV is about ten times as large as that in the case of 5 kV. Accordingly, in order to perform observation with a high X-ray count rate, there is a need for adjusting current quantity so as to correspond to an acceleration voltage.

Fig. 4 is a flow chart showing setting of an operation condition of the electron beam optical system. With the present embodiment of the invention, as shown in Fig. 4, after setting an acceleration voltage at first, an initial value of current strength is set to, for example, 100 pA, the wafer 20 is irradiated, and the main controller 100 receives an X-ray count rate from the X-ray detector controller 101. The main controller 100 increases or decreases current strength of the electron beam 8 so as to correspond to the X-ray count rate. As a result of such a step of operation as described, the X-ray count rate is set to an optimum value for detection of X rays, in a range of 1000 to 2000 cps. However, since a maximum value of electron beam current is dependent on an instrument in use, the beam

current is set to the maximum value of the instrument in case a set value as above comes to exceed the maximum value.

Fig. 5 is a profile showing an X-ray spectrum of a foreign particle of titanium (Ti), 50 nm thick, present on the surface of a silicon wafer, obtained as a result of setting the operation condition of the electron beam optical system, as described above. The height (count-number from a background X-ray signal level) of a Ti-L line peak appearing at 0.45 keV of X-ray energy becomes about 150 counts, higher by about one order of magnitude during equivalent measuring time, as compared with the X-ray spectrum of the foreign particle of titanium (Ti), obtained with the acceleration voltage with at 5 kV, as shown in Fig. 20, thereby obtaining a peak height sufficient for analysis, so that elemental analysis with a high S/N ratio can be attained. Hence, observation with high resolving power and high precision becomes possible.

Second Embodiment

A second embodiment of an electron microscope including an apparatus of x-ray analysis, and a method of analyzing specimens using the same, according to the invention, is described hereinafter with reference to Fig. 3 and Figs. 6 through 8. Fig. 6 is a flow chart showing a method of analyzing X-ray spectra. Figs. 7 and 8 are views

showing an X-ray spectrum and output results of analysis, shown on a display of a main controller, respectively.

An X-ray detector controller 101 according to the present embodiment, which is the same in configuration as that shown in Fig. 3, has a qualitative analysis function of presuming a candidate element on the basis of an X-ray energy value corresponding to a peak of an X-ray spectrum, and other functions as described hereinafter. Further, the X-ray detector controller 101 has a memory, and a database containing a plurality of X-ray spectra (reference spectra), against which an X-ray spectrum as obtained is checked, is stored in the memory. Individual reference spectra are designated by specimen names corresponding thereto, respectively. The reference spectra are prepared for substances used in manufacturing semiconductor elements, such as silicon, oxygen, copper, tungsten, gold, titanium, tantalum, titanium nitride TiN, tantalum nitride TaN, silicon dioxide $SiO2$, and so forth. Furthermore, a main controller 100 is capable of exchanging information with the X-ray detector controller 101, and has functions of controlling the X-ray detector controller 101, receiving necessary information from the X-ray detector controller 101 to thereby show the information on a display of the main controller 100, and storing the information in the memory.

In accordance with the flow chart shown in Fig. 6, the method of analyzing the specimens is described hereinafter. First, qualitative analysis is performed on an X-ray spectrum of a foreign particle, obtained as described in the first embodiment, and the X-ray spectrum and results of the qualitative analysis are shown on the display as shown in Fig. 7. In Fig. 7, element names displayed above respective peaks of the X-ray spectrum represent the results of the qualitative analysis. Next, a region for use in checking the X-ray spectrum against the database is set up. The region for use in checking is referred to an ROI (region of interest). With the present embodiment, a plurality of the ROIs are set up so as to include a portion of the base, corresponding to the respective peaks of the X-ray spectrum, as shown in Fig. 7. The ROIs are set up by a method of deeming portions of the X-ray spectrum, on the upper side of the background, that is, on the plus side thereof, as the ROIs. After setting up the ROIs, the ROIs and numbers corresponding thereto are displayed by double-headed arrows, respectively (highlighting of the ROIs). In the case where peaks of the X-ray spectrum are overlapped with each other, as with the case of an ROI indicated by #1 in Fig. 7, this is deemed as one ROI. Subsequently, for each of the ROIs that are set up, the X-ray spectrum is checked against X-ray spectra in the database stored in the memory

of the X-ray detector controller 101 (matching). Fig. 8 shows results of matching, displaying three lists in descending order of matching scope and degree of matching for each of the ROIs. The degree of matching is evaluated

5 by X2 represented by the following expression:

$$x^2 = \sum_{i=m1}^{m2} (aT_i - L_i)^2 / L_i \quad \ldots \text{ expression (1)}$$

where Ti, Li represent the value of the X-ray spectrum to be checked, and respective values of the X-ray spectra in the database, respectively, m1, m2 are energy at a start

10 point and an end point, of the respective ROIs, respectively, and a is parameter for use in aligning the height of a peak in the respective ROIs with that of the reference spectra to be checked against. In case there exist a plurality of peaks within each of the ROIs, the highest

15 peak is used for matching. On the presumption that the smaller the value of X^2, the better the degree of matching is, there are displayed results showing X^2, a, respective labels of the reference spectra in descending order of degree of matching. With the present embodiment, matching

20 is performed for the full range of acquired energy besides the ROIs as set up, outputting results of such matching as shown in the bottom row of a table in Fig. 8. This is effective for analysis of very thick foreign particles.

In Fig. 8, columns denoted by best, second, and third, respectively, indicate descending order of the degree of matching. The X-ray spectrum obtained is shown to have best matched with the reference spectrum with a label designated

5   as TiN (titanium nitride). In the column of energy regions, start values and end values are shown in units of keV, respectively. It becomes possible to obtain information concerning an element or thickness of a substance, corresponding to the parameter a, on the basis of the

10   parameter a.

The main controller 100 stores information shown in the table in Fig. 8 together with secondary electron images, reflection electron images, and position information, in the memory, and displays elemental distribution of the

15   foreign particle on a wafer on the basis of the position information and the information shown in the table in Fig. 8. Furthermore, the main controller 100 provides a user with presumed results concerning causes for generation of the foreign particle by checking against a database showing

20   relationship with processing steps.

As described in the foregoing, with the present embodiment, since the X-ray spectrum as obtained is checked against the X-ray reference spectra in the database for each of the ROIs, it becomes possible to avoid a problem that

25   respective X-ray spectra of foreign particles come to

significantly differ from each other depending on the size (thickness) thereof even if the foreign particles are the same in elemental composition, resulting in failure to match with any of the X-ray reference spectra stored in the

5   database. This will eliminate the need for preparing X-ray reference spectra for foreign particles with varied thickness, so that the number of X-ray reference spectra to be checked against can be reduced, thereby enabling matching to be executed with high throughput.

10   In the case where X-ray detection of a foreign particle of tungsten is performed by an electron beam with the acceleration voltage at 5 kV, the characteristic X-ray peak attributable to tungsten comes to be overlapped with the characteristic X-ray peak attributable to silicon or

15   tantalum (Ta), so that it is difficult to discriminate therebetween by merely observing X-ray spectra thereof. However, with the use of this method, it has since become possible to discriminate therebetween with high precision. With the present embodiment, in executing matching for each

20   of the ROIs, there are displayed matching results of up to three cases in descending order of degree of matching, however, there may be displayed instead matching results of cases where X2 as an indicator of the degree of matching is not greater than a predetermined value. Further, the ROIs

25   are set up automatically, however, a method of a user setting

up the ROIs by inputting the same may be used in combination with the foregoing method. Furthermore, X2 represented by the expression (1) is adopted as the indicator of the degree of matching, however, it is to be pointed out that the

5   advantageous effects of the invention are not impaired by use of another method of adopting the sum of the square of remainder between both the X-ray spectra, and so forth, as an indicator of the degree of matching.

10 Third Embodiment

A third embodiment of the invention is described hereinafter with reference to Fig. 9. With the present embodiment, the configuration of an instrument is the same as that described in the first and second embodiments,

15 respectively, but a method of analyzing specimens differs from that for the first embodiment and the second embodiments, respectively.

As shown in Fig. 9, with the present embodiment, firstly, X-ray spectra of a plurality of foreign particles

20 to be evaluated are obtained beforehand, and are stored in a designated region of the memory provided in the X-ray detector controller 101 shown in Fig. 3 (a group of X-ray spectra of foreign particles). Respective X-ray spectra are provided with labels corresponding to respective

25 coordinates of positions of the foreign particles, and are

stored so as to be able to identify which of the X-ray spectra corresponds to a foreign particle located at which position.

Subsequently, ROIs are set up for a specific X-ray spectrum of the group of the X-ray spectra of the foreign particles as with the case of the second embodiment, and by checking the specific X-ray spectrum against other X-ray spectra of the group of the X-ray spectra of the foreign particles, the group of the X-ray spectra of the foreign particles is categorized into subgroups of the X-ray spectra having a high degree of matching with each other. Next, one X-ray spectrum is selected from one of the subgroups of the X-ray spectra, as categorized, and is checked against the X-ray reference spectra in the database in accordance with the procedure described in the second embodiment, thereby identifying an element and a substance on the basis of an X-ray reference spectrum matching the respective subgroups.

With the present embodiment, instead of checking the respective X-ray spectra of all the foreign particles for inspection against the X-ray reference spectra, the X-ray spectra of the foreign particles are categorized into the subgroups of the X-ray spectra beforehand, and one X-ray spectrum selected from the respective subgroups is checked against the X-ray reference spectra, thereby identifying an element and a substance. Accordingly, operation on the whole can be implemented with high throughput. This method

is effective particularly in the case where foreign particles on a wafer, as the objects for inspection, are generated due to a certain cause, and are composed of substantially an identical substance.

5   With the first through third embodiments as described above, if the spectral sensitivity of the X-ray detector varies when checking an X-ray spectrum obtained against the X-ray reference spectra in the database, matching precision deteriorates. The spectral sensitivity undergoes variation

10   due to variation with respect to an X-ray detection element of the X-ray detector controller and an X-ray transmission window of the X-ray detector, mounting position of the X-ray detector, relative to the electron microscope (a distance from a specimen to the X-ray detection element, and an X-ray

15   takeout angle), deterioration of transmittance caused by contamination of the X-ray transmission window after mounting, and so forth. Fig. 15 shows a ratio of spectral sensitivity with reference to an X-ray spectrum from the same silicon specimen, obtained by another electron

20   microscope with a different X-ray detector mounted thereon.

With the embodiments of the invention, a ratio of spectral sensitivity in the database to spectral sensitivity at the time of measurement, as shown in Fig. 15, is obtained beforehand, and matching is performed with the

25   ratio of spectral sensitivity described being taken into

consideration in order to prevent deterioration in matching precision, due to variation in spectral sensitivity. In addition, since there can be a case of the spectral sensitivity undergoing a change due to contamination of the X-ray transmission window, and replacement of the X-ray detector, it is preferable to periodically measure a new ratio of spectral sensitivity.

By so doing, the need for preparing a database for every instrument is eliminated, so that it becomes possible to make effective use of the database.

Furthermore, by copying a file for X-ray spectra, the same can be added to the database with ease.

Fourth Embodiment

A fourth embodiment of the invention is described hereinafter with reference to Fig. 5 and Figs. 10 through 14. With the present embodiment, there is shown an example of a method of analyzing the elemental composition of a foreign particle with high precision by electron beam irradiation at varied acceleration voltages.

With the present embodiment, as shown in a flow chart of Fig. 10, firstly, by electron beam irradiation with acceleration voltage at 5 kV, an X-ray spectrum of a foreign particle on a wafer is obtained and is designated as A to be stored in a memory provided in an X-ray detector

controller. Subsequently, by electron beam irradiation with acceleration voltage at 3 kV, an X-ray spectrum of the same foreign particle is obtained and is designated as B to be similarly stored in a memory.

5   Thereafter, an intensity ratio of a spectrum B to a spectrum A (B/A) is calculated, and by comparing B/A with a database, there are displayed results of determination on which element corresponds to the element of the foreign particle, and which element corresponds to the element of

10   a substrate.

A case example is described hereinafter. Figs. 5 and 10 show an X-ray spectrum obtained by irradiating a foreign particle on a wafer with an electron beam with acceleration voltage at 5 kV, and 3 kV, respectively. With either of the

15   X-ray spectra, three characteristic peaks are observed, and are identified as carbon, titanium, and silicon, respectively, in ascending order of energy intensity. Fig. 13 shows an intensity ratio of the X-ray spectrum shown in Fig. 5 to that shown in Fig. 11. For reference, the X-ray

20   spectrum corresponding to the electron beam irradiated with acceleration voltage at 3 kV is shown by a graph in the lower part in the figure. The vertical axis is adjusted for easy viewing, and the horizontal axis indicates X-ray energy intensity. Fig. 14 shows an intensity ratio of an X-ray

25   spectrum of a compound composed of uniformly distributed

titanium and silicon against an electron beam irradiated
with acceleration voltage at 5 kV to the same at 3 kV. The
X-ray spectrum shown in the lower part in the figure is one
corresponding to the electron beam irradiated with

5 acceleration voltage at 3 kV. It can be seen by comparing
Fig. 13 with Fig. 14 that a titanium peak at 0.45 keV of X-ray
energy differs in trend from a silicon peak at 1.75 keV of
X-ray energy. More specifically, in a part (background
X-ray) of Fig. 13 as well as Fig. 14, having no peak, a curve

10 is shown to fall downward toward the right, and in the case
of a specimen of the compound composed of uniformly
distributed titanium and silicon (Fig. 14), the curve has
a downward dent at points thereof, corresponding to the
respective intensity ratios at the peaks of titanium and

15 silicon, respectively. In contrast, in the case of the
foreign particle (titanium) on the wafer (Fig. 13), the
curve has an upward bulge at a point thereof, corresponding
to the intensity ratio at the peak of titanium while the
curve has a downward dent at a point thereof, corresponding

20 to the intensity ratio at the peak of silicon. Furthermore,
the downward dent in Fig. 13 is shown to be a further deeper
dent in comparison with that in the case of the specimen of
the compound composed of uniformly distributed titanium and
silicon. On the basis of the above finding, there are

25 displayed results of determination that titanium is the

element of the foreign particle, and silicon is a substance underneath the foreign particle.

Fig. 12 shows scattering conditions of electrons inside a specimen of a titanium thin film 50 nm thick, attached to the top of a silicon substrate, as calculated by a Monte Carlo method. Fig. 12A shows a calculation result in the case of electron beam irradiation at 3 kV of acceleration voltage, and Fig. 12B shows a calculation result in the case of electron beam irradiation at 5 kV of acceleration voltage. A proportion of electrons penetrating through the titanium thin film to be scattered inside the silicon substrate in the case of the acceleration voltage at 3 kV is higher that that in the case of the acceleration voltage at 5 kV. Accordingly, X-rays produced by the electron beam irradiation at 3 kV of the acceleration voltage represent more X-rays emitted from substance in the vicinity of the surface, that is, titanium, than those emitted from the substrate, that is, silicon. The above-described results of the determination based on difference in graph between Figs. 13 and 14 are derived by taking advantage of such a phenomenon as described. That is, with the present embodiment, it becomes possible to provide information concerning elemental distribution from an intensity ratio between X-ray spectra as observed,

so that a cause of generation of a foreign particle can be searched for with greater accuracy.

With the present embodiment, there is shown the method of identifying elements of a foreign particle with X-ray spectra emitted by electron beam irradiation at two varied acceleration voltages. Now, referring to Figs. 16, and 17, there is described hereinafter another method of identifying elements of a foreign particle by use of three varied acceleration voltages. Figs. 16A through 16C are schematic representations for illustrating the principle on which this method is based, and Figs. 17A through 17C are schematic diagrams of X-ray spectra. As shown in Figs. 16A through 16C, this method is effective not for a process step as an object for inspection, but for analysis of a foreign particle called a foreign particle abnormal in shape, generated due to a foreign particle 22 immediately before the process step. In Figs. 16A through 16C, reference numeral 21 denotes a substrate after a step proceeding to the process step as the object for the inspection, and 26 denotes a film formed in the process step as the object for the inspection. Figs. 16C is a sectional view showing a portion abnormal in shape, generated due to the foreign particle 22 formed immediately before the process step as the object for inspection. First, as show in Fig. 16A, the portion abnormal in shape is irradiated with an electron

beam 8 at an acceleration voltage selected so as not to pass through the film 26, whereupon the electron beam 8 scatters in an electron scattering region 71, and only a characteristic X-ray peak 72 of the element of the film 26 is observed as shown in Fig. 17A. Fig. 16B shows a case of irradiation with an electron beam 8 having an acceleration voltage higher than that for the electron beam 8 in Fig. 16A. With the acceleration voltage getting higher, the electron beam scatters inside the foreign particle 22 as shown by an electron scattering region 71. In this case, as shown in Fig. 17B, besides the characteristic X-ray peak corresponding to the element of the film 26, a characteristic X-ray peak 73 corresponding to the element of the foreign particle 22 is observed. Next, as shown in Fig. 16C, an electron beam 8 having a still higher acceleration voltage is irradiated, whereupon the electron beam 8 comes to scatter inside the substrate 21 in the step proceeding to the process step for the inspection, as indicated in the figure, so that a characteristic X-ray peak 74 corresponding to the element of the substrate 21 is observed. Thus, with this method, it becomes possible to obtain information concerning the element of the foreign particle 22.

The invention has advantageous effects as follows. That is, with the above-described embodiments of the

invention, it becomes possible to observe foreign particles on the surface of a specimen by electron beam irradiation on condition that X-ray spectra from the foreign particles can be detected with high resolving power and high

5 efficiency while high precision matching with reference spectra can be implemented and effective analysis can be performed even with a few reference spectra even in case there occur problems at the time of X-ray analysis by excitation with an electron beam at low acceleration

10 voltages, considered effective for observation of elements of the foreign particles as the objects of inspection with high space resolving power, that is, in the case where characteristic X-rays that can be excited are restricted, peaks of the characteristic X-ray that can be excited are

15 overlapped with each other, and the X-ray spectra of the foreign particles are mixed with the X-ray spectrum of a substrate underneath the foreign particles. Furthermore, it is also possible to obtain information concerning distribution of observed elements inside the specimen.

20 Thus, elemental analysis with high precision and high sensitivity can be performed, and it becomes possible to provide an electron microscope including an apparatus of x-ray analysis, capable of performing inspection of foreign particles for enhancement of yields in manufacturing LSI

25 device and so forth, attaining further miniaturization,

with high precision, and high space resolving power, and a method of analyzing specimens using the same.

What is claimed is:

1. An electron microscope having an electron beam optical system provided with an electron source and a lens for focusing an electron beam, an optical system controller
5 for controlling the electron beam optical system, a specimen stage on which a specimen is to be placed, an electron detector for detecting electrons emitted from the specimen by irradiating the specimen with the electron beam, an X-ray detector for detecting X rays radiated from the specimen,
10 and a processor for processing signals from both the detectors, and performing image formation and elemental analysis of the specimens, said electron microscope comprising:

a database having data including X-ray spectra
15 (reference spectra) of a plurality of kinds of standard substances and labels containing names of substances corresponding to the respective reference spectra; and

means comprising steps of:

checking an X-ray spectrum (sample spectrum) of the
20 specimen against the reference spectra in the database;

calculating degree of matching in spectral shape between the sample spectrum and the reference spectra;

extracting a reference spectrum having the highest degree of matching from the database;

setting up a plurality of X-ray energy regions so as to have sensitivity data for X-ray energy of the X-ray detector, and to include peaks of the sample spectrum when analyzing by identifying a substance of the specimen on the

5   basis of the label corresponding to the reference spectrum extracted;

standardizing intensity of the reference spectra into intensity of the sample spectrum for each of the X-ray energy regions as set up after multiplying the reference spectra

10   by the sensitivity data;

checking the sample spectrum against the reference spectra as standardized and extracting one or a plurality of the reference spectra in descending order of the degree of matching between the sample spectrum and the reference

15   spectra for each of the X-ray energy regions; and

outputting the label or labels corresponding to the one or the plurality of the reference spectra, degree of matching, and a numerical value used in the standardization.

2. An electron microscope according to claim 1,

20   wherein a function of outputting the label, the degree of matching, and the numerical value used in the standardization outputs a first candidate element, first to second candidate elements, or first to third candidate elements in descending order of the degree of matching.

3. An electron microscope according to claim 1, wherein a intensity ratio of the sample spectra obtained by electron beam irradiation at not less than two varied acceleration voltages is displayed.

5   4. An electron microscope according to claim 1, wherein the sensitivity data contain a ratio of an intensity of an X-ray spectrum of a standard specimen including a silicon wafer, obtained at the time of obtaining the reference spectra to an intensity of an X-ray spectrum of

10   the standard specimen, obtained immediately before matching.

5. An electron microscope having an electron beam optical system provided with an electron source and a lens for focusing an electron beam, an optical system controller

15   for controlling the electron beam optical system, a specimen stage on which a specimen is to be placed, an electron detector for detecting electrons emitted from the specimen by irradiating the specimen with the electron beam, an X-ray detector for detecting X rays radiated from the specimen,

20   and a processor for processing signals from both the detectors, and performing image formation and elemental analysis of the specimens, said electron microscope comprising:

a database having data including X-ray spectra

25   (reference spectra) of a plurality of kinds of standard

substances and labels containing names of substances corresponding to the respective reference spectra;

a memory for storing a plurality of X-ray spectra (sample spectra) at a plurality of observation points on the specimen, respectively, obtained by the X-ray detector; and

means of categorizing the plurality of the sample spectra into one or a plurality of groups of the sample spectra by matching thereof with each other, and performing elemental analysis of one X-ray spectrum selected from the respective groups.

6. An electron microscope according to claim 5, further comprising a function of matching the sample spectra with each other for each of one or a plurality of X-ray energy regions set up so as to include respective peaks of the sample spectra when executing the matching of the sample spectra with each other.

7. An electron microscope having an electron beam optical system provided with an electron source and a lens for focusing an electron beam, an optical system controller for controlling the electron beam optical system, a specimen stage on which a specimen is to be placed, an electron detector for detecting electrons emitted from the specimen by irradiating the specimen with the electron beam, an X-ray detector for detecting X rays radiated from the specimen, and a processor for processing signals from both the

detectors, and performing image formation and elemental analysis of the specimens, said electron microscope comprising:

means of detecting the count-number of X rays per unit
5 time by detecting the X rays with the X-ray detector, and

feedback-controlling current quantity of the electron beam on the basis of the count-number of X rays per unit time.

8. An electron microscope according to claim 7,
10 wherein the current quantity of the electron beam is feedback-controlled such that the count-number of X rays from the specimens falls within a range of 1000 to 2000 counts per second.

9. A method of analyzing specimens, using an electron
15 microscope having an electron beam optical system provided with an electron source and a lens for focusing an electron beam, an optical system controller for controlling the electron beam optical system, a specimen stage on which a specimen is to be placed, an electron detector for detecting
20 electrons emitted from the specimen by irradiating the specimen with the electron beam, an X-ray detector for detecting X rays radiated from the specimen, a processor for processing signals from both the detectors, and performing image formation and elemental analysis of the specimens, and
25 a database having data including X-ray spectra (reference

spectra) of a plurality of kinds of standard substances and labels containing names of substances corresponding to the respective reference spectra, said method of analyzing the specimens comprising steps of:

5   checking an X-ray spectrum (sample spectrum) of the specimen against the reference spectra in the database;

calculating degree of matching in spectral shape between the sample spectrum and the reference spectra;

extracting a reference spectrum having the highest

10   degree of matching from the database;

setting up a plurality of X-ray energy regions so as to have sensitivity data for X-ray energy of the X-ray detector, and to include peaks of the sample spectrum when analyzing by identifying a substance of the specimen on the

15   basis of the label corresponding to the reference spectrum extracted;

standardizing intensity of the reference spectra into intensity of the sample spectrum for each of the X-ray energy regions as set up after multiplying the reference spectra

20   by the sensitivity data;

checking the sample spectrum against the reference spectra as standardized and extracting one or a plurality of the reference spectra in descending order of the degree of matching between the sample spectrum and the reference

25   spectra for each of the X-ray energy regions; and

outputting the label or labels corresponding to the one or the plurality of the reference spectra, the degree of matching, and a numerical value used in the standardization.

10. A method of analyzing specimens, using an electron microscope having an electron beam optical system provided with an electron source and a lens for focusing an electron beam, an optical system controller for controlling the electron beam optical system, a specimen stage on which specimens are to be placed, an electron detector for detecting electrons emitted from the specimens by irradiating the specimens with the electron beam, an X-ray detector for detecting X rays radiated from the specimens, a processor for processing signals from both the detectors, and performing image formation and elemental analysis of the specimens, a database having data including X-ray spectra (reference spectra) of a plurality of kinds of standard substances and labels containing names of substances corresponding to the respective reference spectra, and a memory for storing a plurality of X-ray spectra (sample spectra) at a plurality of observation points on the specimens, respectively, obtained by the X-ray detector, said method of analyzing the specimens comprising:

means of categorizing the plurality of the sample spectra into one or a plurality of groups of the sample

spectra by matching thereof with each other, and performing elemental analysis of one X-ray spectrum selected from the respective groups.

ABSTRACT

There are provided an electron microscope including
an apparatus of x-ray analysis, capable of performing
elemental analysis with X-rays emitted from a specimen by
electron beam irradiation, that is, inspection of foreign
particles, for enhancement of yields in manufacturing
semiconductor devices and so forth, at high speed and with
high precision and high space resolving power, and a method
of analyzing specimens using the same. The electron
microscope comprises means of automatically controlling
current quantity of the electron beam such that an X-ray
count rate falls within a range of 1000 to 2000 counts per
second, means of setting up a plurality of X-ray energy
regions when checking an X-ray spectrum against reference
spectra stored in a database for analysis of the X-ray
spectrum, and performing matching for each of the X-ray
energy regions, and means of analyzing distribution of
elements observed on the basis of an intensity ratio between
X-ray sample spectra obtained by electron beam irradiation
at not less than two varied acceleration voltages,
respectively.